especially effective, as will be described in detail hereunder, the film (3) will be useless as the MR ratio therein is lowered.

For the two reasons mentioned above, the idea of the film constitution (3) is exclusively for the region where the free layer is relatively thick, and it is understood that the idea is useless in preparing practicable films having an ultra-thin free layer.

Comparative Case 4: Synthetic AF with no spin filter

5 nanometer Ta/2 nm NiFe/0.5 nm CoFe/2 nm Cu/2.5 nm CoFe/0.9 nm Ru/2 nm CoFe/7 nm IrMn/5 nanometer Ta (4)

In this Comparative Case, employed is a Synthetic AF structure for the purpose of improving the pinning characteristics. The two ferromagnetic layers are antiferromagnetically coupled to each other via Ru (ruthenium). One of the two ferromagnetic layers is pinned to the other via an antiferromagnetic layer existing therebetween. Even if the uni-directionally anisotropic magnetic field Hua is too small for normally pinned structures, but if it is on a certain level, such a small Hua is applicable to the Synthetic AF structure, and the pinning resistance of the Synthetic AF structure is high. As previously mentioned hereinabove, in the Synthetic AF structure, the magnetization directions of the upper and lower ferromagnetic layers as coupled via Ru are opposite to each other, and the coupling magnetic field is several kOe and is much larger than the medium magnetic field for head operation.

Approximately for the magnetic moment running outward, therefore, it is considered that the difference in MsXt between the upper and lower pinned layer will be equal to the net moment. Specifically, it is possible to reduce the influence of the magnetic field strayed from the pinned layer to the free layer, and it is expected that the reduction is advantageous for the bias point (see USP No. 5,465,185).

For example, in this Comparative Case, it is considered that the net pinning thickness will be equivalent to the pinned layer having a thickness of 0.5 nanometers, and it is possible to realize the pinned layer stray magnetic field equivalent to the thin pinned layer, which, however, could not be realized in normal pinning structures. Ideally, when the upper and lower pinned layers are controlled to have the same product of MsXt, then the pinned layer stray magnetic field could be zero. It has heretofore been considered that only the reduction in the pinned layer stray magnetic field will be satisfactory for good bias point designing for spin valve films for high-density recording. This time, however, we, the present inventors have found that, if only the Synthetic AF structure is employed, it is impossible to realize stable bias points in ultra-thin free layers applicable to high-density recording. The matters we have found are described in detail hereunder.

Fig. 14 is a conceptual view showing the determinant

factors for the bias point in this Comparative Case 4. Specifically, in the constitution of this Comparative Case, the free layer is positioned, being much far from the current center of the current distribution in the spin valve film. In this, therefore, the current magnetic filed Hcu is extremely large. Hin is at most 20 Oe or so, and the pinned layer stray magnetic field is extremely reduced owing to the Synthetic AF structure employed. This means that the film constitution of this Comparative Case 4 is nearly in the just bias condition in the absence of current. When current is applied to the spin valve film of this constitution, and when the applied current is increased, then the film will much overstep the just bias condition owing to the increased current magnetic field Hcu.

The calculated bias point data of this Comparative Case are shown in Table 4.

Table 4

Calculated Bias Point Data of Film of Comparative Case 4

MR height	Hcu↑Hpin↑	Hcu↓Hpin↓
0.3 μm	88 %	22 %
0.5 μm	80 %	16 %
0.7 μm	73 %	10 %

Hin is 20 Oe. As so anticipated, it is understood from Table 4 that the bias point could not fall the range of from 30 to 50 % irrespective of the direction of the current flow.

For obtaining the just bias in this constitution, one